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ABSTRACT

This paper examines the process by which an immediate access-to-technology environment influences the frequency, form, and substance of collegial interaction among classroom teachers. The longitudinal study, part of the Apple Classrooms of Tomorrow project, covers a 5-year period and utilizes data from 32 elementary and secondary teachers in five schools located in four different states. Over time, teachers' interactions moved from informal, infrequent exchanges to structured technical assistance to formalized team teaching and cooperation. Using electronic mail, correspondence between sites, and audiotapes on which teachers reflected about their experiences, researchers discovered that the new patterns of teaching and learning can be viewed as an evolutionary process similar to other models of educational change. Five stages were identified: entry, adoption, adaptation, appropriation, and invention. Differences in teacher attitudes and the organizational structure at the elementary and secondary levels led to different types of obstacles in team teaching. Several advantages of teamwork are noted, and experiences of selected teachers are provided. It is concluded that access to technology drove teachers to more collegial interaction and provided a measure of professional development. (31 references) (Author/DB)

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The Relationship Between Technological Innovation and Collegial Interaction

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Prepared for a presentation at the 1991 meeting of the American Educational Research Association, Chicago.

Apple Classrooms of Tomorrow℠ (ACOT℠)
A Project of the Advanced Technology Group
Apple Computer, Inc.

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Abstract

This paper examines the process by which an immediate-access-to-technology environment influences the frequency, form, and substance of collegial interaction among classroom teachers. The longitudinal study covers a five year period and utilizes data from 32 elementary and secondary teachers in five schools located in four different states. Over time, teachers' interactions moved from informal, infrequent exchanges to structured technical assistance to formalized team teaching. However, the process of building collaboration was lengthy, involved overcoming numerous obstacles, and varied for elementary and secondary teachers.

THE RELATIONSHIP BETWEEN TECHNOLOGICAL INNOVATION AND COLLEGIAL INTERACTION

Judith Haymore Sandholtz
Cathy Ringstaff
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> We have all grown a lot in this program because we are usually not asked to work together like this in our profession. . . But [one team member] is really a problem. . . [This person] is an extremely difficult team player—selfish, self-centered, and stubborn. . . I don't know if there have been problems like this at other sites but it can really break a team up. (AT, 7240, 2/21/89)[1]

During a period of reflection, Mary Barton points out highs and lows of working closely together in a team. Teacher isolation, a common feature in school settings, inhibits collegial sharing and teacher growth. Yet the formation of teams is not a quick cure. While teacher collaboration offers many benefits to teachers and students, the process of building collaboration is slow and filled with obstacles. As one of 32 teachers involved in the Apple Classrooms of Tomorrow^{sm} (ACOT^{sm}) project, Mary has experienced changes in both instruction and collegial interaction resulting from technological innovation.

In 1985, Apple Computer began a collaboration with a number of schools throughout the country to investigate learning and teaching when children and teachers have access to interactive technologies. Students and teachers in the Apple Classrooms of Tomorrow project had constant access to a variety of technological tools such as computers, printers, laserdisks, camcorders, scanners, and a multitude of software programs.

ACOT's mission is formative: to explore, develop, and demonstrate powerful uses of technology in teaching and learning. As an agent of change, the program seeks to influence educational reform by implementing the following goals as an ongoing process:

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[1]The data notation system used throughout this paper indicates the source of the data (AT = audiotape data; WL = weekly reports sent via electronic mail; SL = links sent between sites), the episode's entry number in the database, and when the data were generated.

- Build active, creative learning environments where children and teachers have immediate access to interactive technologies;
- Study how these environments affect teaching and learning;
- Document and share results with parents, educators, policymakers, and technology developers; and
- Use findings to recreate the vision.

One research project that has emerged from this collaborative effort looks at teachers' experiences in these immediate-access-to-technology classrooms. This paper stems from that project and addresses the process by which the innovative environment influenced the frequency, form, and substance of collegial interaction among the teachers. Over time, teachers' interactions moved from informal, infrequent exchanges to structured technical assistance to formal team teaching.

Researchers identify regular opportunities for interaction with colleagues as an important feature of a successful work environment (Purkey & Smith, 1983); teacher interaction in effective schools tends to be frequent, task focused, and widespread (Little, 1982; Rutter, Maughan, Mortimore, & Ouston, 1979). However, in many schools, opportunities for interaction are limited, and communication tends to be informal and infrequent even though teachers believe their teaching could be improved by working with colleagues (Corcoran, 1988). In addition, teacher attitudes and workloads may inhibit interaction and collaboration.

Attempts to increase interaction typically involve formalized restructuring efforts. Instructional arrangements are realigned so that teachers work together in various types of teams or units. In some cases, teams are organized across grade levels and across disciplines. These types of changes in school structures increase the incidence of collaborative teaching and the overall amount of task-related communication (Charters, 1980). Moreover, students in team-taught classes show better attitudes toward school (Sigurdson, 1982; Cotton, 1982), decreased discipline problems (Schmidt & Kane, 1984), and achievement gains (Costello, 1987; Schmidt & Kane, 1984; Sigurdson, 1982). However, teachers demonstrate reluctance to sustain team allegiance over time (Charters, 1980) and need long-term assistance in order to make teaming work effectively and efficiently (Rutherford, 1981).

Another line of research investigates the success and failure of educational innovations. Innovation can be extremely difficult to institutionalize because homeostatic forces in schools are more powerful than innovative forces (Joyce, 1982). In addition, teachers may resist change because the innovation comes from policymakers or

nonteaching experts (Butt, 1984; Common, 1983) with little exchange between outsiders and practitioners about what curricular innovations mean in various classrooms (Swanson-Owens, 1985). Serious commitment from teachers occurs only after teachers use the new program and innovation and see that it really does assist them in teaching their students (Gersten & Guskey, 1985). However, these types of changes do not occur quickly but evolve over a period of time (Dwyer, Ringstaff, & Sandholtz, 1990; Gersten & Guskey, 1985). In addition to identifying time as a critical resource, researchers point to the importance of a supportive organizational environment and collegial sharing in moving teachers toward the adoption of innovations (Educational Technology Center, 1985; Joyce, 1982; Henson, 1987).

This paper links these two areas of research by examining the relationship between collegial interaction and technological innovation in elementary and secondary classrooms. It examines the symbiotic relationship between innovation and collegial interaction, identifying both facilitating factors and obstacles.

SETTINGS

This qualitative study utilizes data from thirty-two elementary and secondary teachers in five schools located in four different states. The ACOT schools represent the diverse populations and conditions found in contemporary public schooling. Each of these sites began with one classroom in the fall of 1986, adding classrooms, staff, and students in subsequent years. Table 1 summarizes the status of each site in the spring of 1990.

Site	Grades	Teachers	Students	Community/SES
1	1-4	8	180	Suburban/High
2	5-6	7	180	Rural/Middle
3	4-6	4	90	Inner-City/Low
4	4 & Sp. Ed.	4	80	Suburban-Urban/Low-Middle
5	9-12	9	120	Urban/Low-Middle

Table 1: Site Descriptors

In each of these settings, students and teachers have constant access to interactive technologies. The elementary classes are equipped with Apple IIe, IIGS, and Macintosh computers. The high school is an all Macintosh installation. In addition to the computers, classrooms are equipped with printers, scanners, laserdisks and videotape players, modems, CD Rom drives, and hundreds of software titles.

The technology is used as a tool to support learning across the curriculum. No attempt is made to replace existing instructional technologies with computers. By design, the classrooms are true multimedia environments where students and teachers use textbooks, workbooks, manipulative math materials, white boards, crayons, paper, glue, overhead projectors, televisions, pianos, etc. as well as computers. The operating principle is to use the media that best supports the learning goal.

The ACOT project provides a variety of supports for teachers with the goals of increasing teachers' knowledge of research theories on teaching and learning, expanding their technical expertise, and encouraging them to share acquired knowledge and skills. This support ranges from holding conferences and training workshops to providing technical equipment and professional release time. In addition, all sites are linked by a telecommunications network that permits teachers to communicate with teachers at other sites as well as ACOT staff.

DATA COLLECTION AND METHODOLOGY

The sources of data for this study, covering from October 1985 through June 1990, include weekly reports sent via electronic mail; correspondence between sites, and bi-monthly audiotapes on which teachers reflected about their experiences. Although this study does not include observational data, hundreds of hours of systematic observations by independent researchers (e.g., Gearhart, Herman, Baker, Novak, and Whittaker, 1990; Tierney, 1988) support the self-report data reported in this investigation.

The research team transcribed all written communications and summarized the audiotapes. To facilitate analysis, narratives were divided into episodes; each episode represents an event, with a beginning, middle, and end. Episodes were indexed for retrieval using a variety of categories and subcategories (e.g., participant, affective tone, context, general theme). The development of content categories followed the principles of "grounded theory" (Glaser & Strauss, 1967), "progressive focusing," (Hamilton, MacDonald, King, Jenkins, & Parlett, 1977), and "collapsing outlines" (Smith, 1978). The indexing system allows sorting and rapid retrieval of descriptive, qualitative data along a number of dimensions for the construction of reports. Important themes and events emerge from the data in the "constant comparison" mode (Glaser & Strauss, 1967).

The data have been divided into two databases, which together have almost 20,000 episodes. A relational database, Double Helix, is used to manage and analyze the data. This software allows data to be organized in a multitude of ways (e.g., by teacher, by school site, by dates, by thematic categories). Since the project spans almost five years, some of

the teachers represented in the database were not involved for this entire time. Thus, simply examining individual teachers' data in terms of chronological dates could be misleading. In addition, each year of the project sometimes brought about changes in site organization, in the types of available equipment, or in project goals. At some sites, teachers worked with the same group of teachers and students over several years, while at other schools the key players changed more frequently. Therefore, rather than examining change within individual teachers over time, we viewed the data as a "collective consciousness," documenting general trends related to collegial interaction during the evolution of the project. (For a thorough discussion of the data collection strategies and methodology used in this study, please see Dwyer, Ringstaff, Sandholtz, Keirns, & Grant [1990]).

RESULTS

Our investigation suggests that innovations, such as high-access-to-technology classrooms, tended to drive teachers to engage in more collegial interaction and instructional sharing in order to prepare for their classes and update their curriculum. The reverse was also evident: teachers in schools with a high level of collegial interaction tended to embrace innovations and implement new instructional strategies more quickly. However, the process of building collaboration among teachers took time, involved overcoming numerous obstacles, and varied for elementary and secondary teachers.

This paper deals primarily with the collegial interaction among teachers rather than instructional changes. However, the two areas are closely related. The changes that occurred in instructional areas linked closely with the changes in collegial interaction, each enhancing the other. Figure 1 displays the new patterns of teaching and learning that emerged over time. This progression can be viewed as an evolutionary process similar to other models of educational change (e.g., Berman & McLaughlin, 1976; Giacquinta, 1973; Gross & Herriott, 1979). The five stages of instructional evolution in the ACOT classrooms include: Entry, Adoption, Adaptation, Appropriation, and Invention. In this model, text-based curriculum delivered in a lecture-recitation-seatwork mode is first strengthened through the use of technology and then gradually replaced by far more dynamic learning experiences for the students. (For a more thorough treatment of the changes in instructional practices, see Dwyer, Ringstaff, & Sandholtz [1990]).

Figure 2 depicts the relationship between the instructional evolution and the collegial interaction of teachers. Corresponding to the gradual instructional shifts are changes in the frequency and form of collegial interaction. At the beginning of the project, interaction was infrequent and focused on emotional support. Over time, teachers'

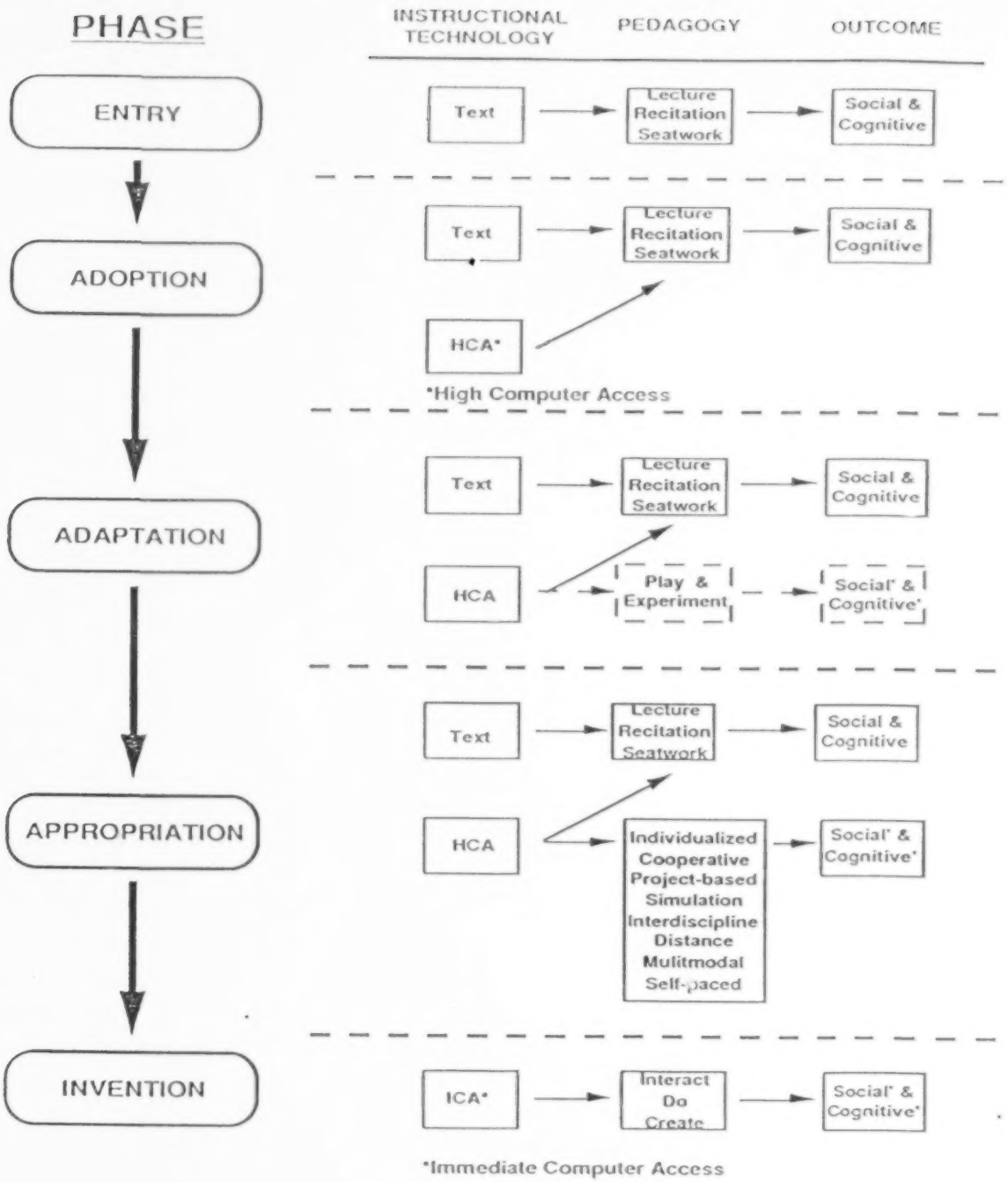

Figure 1: Instructional Evolution in Technology–Intensive Classrooms

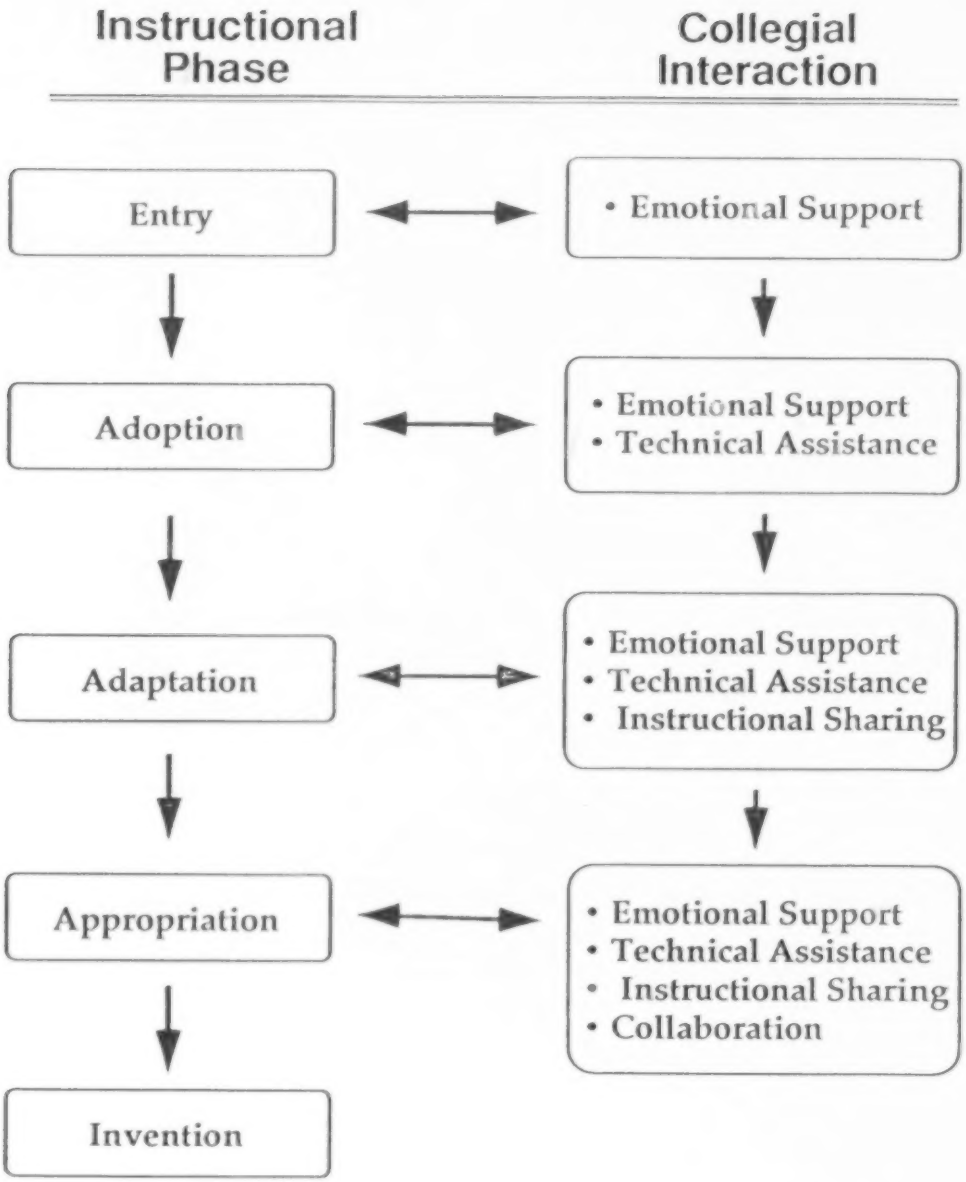

Figure 2: The Relationship between Instructional Evolution and Collegial Interaction of Teachers

interactions shifted to include technical assistance, instructional sharing, and, eventually, formalized collaboration. Table 2 summarizes the main differences among the categories of collegial interaction.

Emotional Support	sharing frustrations and successes, providing encouragement
Technical Assistance	managing equipment, using equipment, locating software, using software, dealing with technical problems
Instructional Sharing	discussing instructional strategies, sharing ideas, observing instruction
Collaboration	joint planning, team teaching, developing new methods, interdisciplinary teaching

Table 2. Categories of Collegial Interaction

The following sections briefly summarize the changes in instructional practices and describe the accompanying changes in collegial interaction among the teachers.

Entry/Emotional Support

Instructional Activities

In the entry stage of the project, ACOT teachers had little or no experience with computer technology and demonstrated little inclination to significantly change their instruction. The first weeks of the project involved transforming the physical environment of the classroom — unpacking boxes, running extension cords, untangling cables, inserting cards, formatting, disks, checking out home systems. Once instruction began, experienced teachers faced typical first-year-teacher problems such as discipline, resource management, and personal frustration (See Sandholtz, Ringstaff, & Dwyer [1990] for a full discussion of classroom management issues.) Teachers began using their technological resources but simply to replicate traditional instructional and learning activities.

Teacher Interaction

During the first weeks of the project, teachers had little time for collegial interaction even though the supports for such interaction, such as professional release time, training workshops, and a telecommunications network between sites, were available. As the year progressed, the frequency of interaction among teachers increased as they became involved

in the high-computer-access-classrooms. However, exchanges remained informal, providing emotional support. Teachers shared their frustrations and successes as they dealt with a room full of computers, cables, and children.

> We have been at school all day, but there has not been a delivery [of our computers]. We've cleaned, painted, taken inventory, and talked to software parties. [We] are now pitching boxes out the window. That's what slow delivery does to us. We hope we will have better luck on Monday. It's late for Friday, so we're going home!! (SL, 10622, 8/15/86)

> By this time next week, all of our great dreams will be come reality as we work with the students. We are anticipating a great year and are looking forward to the challenge. I hope I still feel this way next week. (WL, 10222, 8/21/86)

Adoption/Technical Assistance

Instructional Activities

As teachers moved into the adoption stage, their concerns began to shift from connecting the computers to using them. Teachers adopted the new electronic technology to support their established text-based drill-and-practice instruction. Students continued to receive steady diets of whole-group lectures, recitation, and individualized seatwork. Although the physical environments had changed, the instructional strategies remained the same, just using different tools.

Teacher Interactions

As teachers began to utilize the new technology in their instruction, their interactions increased but revolved around providing technical assistance. Teachers in project classrooms, both within and across sites, shared strategies in areas such as managing the equipment and locating relevant software.

> I'm having problems printing with one of our programs. I think that it's a configuration problem, but I can't figure out how to do it. (AT, 6195, 1/30/87)

> You've cleared up a lot of questions for me. I didn't know I could send anything but Microsoft Word over AppleLink. . . Is it better than the others? I'm still pretty new at this. (SL, 11259, 10/19/88)

> [One teacher] has been working on geometry and measurement in math. She is using Logo to demonstrate concepts. The students have really taken to it since they think they are playing. Does anyone have any software that can be used to teach geometry? (WL, 9798, 2/20/87)

Formal meetings among the project teachers at each site provided opportunities for sharing experiences and ideas. Teachers also started to take advantage of weekly reports and the telecommunications network to communicate with teachers at other sites. The technical assistance was not limited to technological concerns but extended to other areas such as dealing with student misbehavior.

> I found out that the kids had put their database information together, and I saw the same entries in my combined database. Unfortunately, I didn't know which student did what entries because I just dumped all of the files into my database. [Another teacher] told me how I can put the student's name in a column and then know what data belongs to what student. (AT, 2746, 10/30/87)

Teachers with less computer expertise approached their colleagues for assistance and capitalized on opportunities to learn from each other.

> At this point, I must say I am feeling a little overwhelmed and will probably continue to feel this way for some time to come. I learned some things this summer, but there is so much more to learn. . . .I have been attending [another teacher's] computer applications class and will continue to attend the rest of the year. (AT, 87, 9/16/88)

Technical assistance among the teachers helped them to adopt the new technology and to begin to utilize it in their instruction, even if simply as a support for their previous instructional style. Conversely, because the teachers began to accept the innovation, they had questions and concerns which compelled them to seek assistance from their colleagues.

Adaptation/Instructional Sharing

Instructional Activities

The adaptation phase brought changes in the efficiency of the instructional process. Students' productivity increased in a variety of areas. For example, students completed a self-paced math curriculum in significantly less time, allowing teachers to engage students in higher-order learning objectives and problem solving. Many students now could type

faster than they could write, thus preparing assignments more quickly and with greater fluency. In addition, they willingly reworked their papers. According to one study, the students not only produced more written work, but the quality improved as a function of the accessibility of computers (Hiebert, 1987). Teachers also noted improved student engagement in classroom tasks.

Teacher Interaction

As teachers began to experiment with learning experiences based on the technology, the substance of their interactions shifted from offering technical assistance to sharing instructional strategies. Collaboration about instructional topics emerged when teachers ventured beyond using the technology for text-based drill-and-practice instruction. Their experimentation motivated them to share their endeavors with other teachers and sites.

> The kids are transposing their music into Logowriter language using sub and super procedures. We then got into doing shapes which resulted in animation. We're using Turtle Graphics for graphics and animation, also including sound effects. The kids love it; they worked solidly at it. It was amazing what they all came up with; they work in cooperative groups so no one gets left out. I'd like to share this with [another] site that has a sixth grade. I'd like to get more communication between the two. (AT, 3432, 2/15/88)

> I read your question about what others do to teach word problems. One thing we've done is to spend a good deal of time having students write word problems for their peers to solve. This serves two purposes. We get a real understanding of what the students understand by reading their word problems and teach careful writing because if students have a question, they first ask the author of the problem. Then, as you teach strategies, encourage students to include those strategies in their word problems (SL, 13241, 2/14/89)

The telecommunications network permitted teachers to communicate across sites and receive prompt answers to their queries. But not all instructional sharing across sites occurred as a result of direct questions. All ACOT teachers had the opportunity to read the weekly reports submitted by each site. This frequently led to unsolicited offers of assistance among teachers.

> Just read your weekly and noticed you'd be doing an autobiography. I wrote up an autobiography unit for my lesson for Apple last year and would be willing to pass it along to you if you think it would be any help. We're having all our fifth and sixth graders write them this year based on this plan. Let me know. (SL, 13406, 1/10/89)

Several sites decided that the benefits of cross-site communication should be extended to the students as well. Some teachers arranged for specific days when the students in their classes could "chat" using telecommunications. Others set up formalized "Applelink pals" arrangements that lasted throughout the school year. Students not only sent letters but also videotapes so the Applelink pals could see each other in the classroom setting. One teacher even arranged for students to communicate with students in Sweden. Teachers at other sites, hearing about the arrangement, requested similar opportunities for their classes.

As teachers began to feel comfortable with increased interaction among both students and teachers, they started to *observe* each other teaching as opposed to simply discussing their instructional ideas. Previously, very few teachers had observed other classrooms, and when they did, the primary purpose was to learn more about the technology rather than to garner instructional ideas.

> The relationships between the students and teachers are unique in ACOT. Very seldom does a teacher in a normal setting get to observe another teacher. . . It's exciting to see each person teach their subject area. It is neat during study hall to see [the other teacher's] contact with the students. (AT, 2602, 2/10/88)

> I acted as an escort for [some visitors] and showed them different classrooms. . . It was very interesting for me because this is the first time for me to see what others are doing in their classrooms and how they're using the computers. I think I'm going to suggest that maybe we do this occasionally to give the teachers some fresh ideas and to share and exchange knowledge and ideas. (AT, 5755, 1/17/89)

Teachers also started to suggest sharing new techniques with teachers at their schools not directly involved in the ACOT project.

> I realized after this conference that I need to share with the other math teachers what we are doing with the graphic calculator and to extend the program to more than the ACOT classes. (AT, 5863, 12/11/88)

Appropriation/Collaboration

Instructional Activities

As teachers eventually reached the Appropriation phase — the point at which an individual comes to understand technology and use it effortlessly as a tool to accomplish real work — their roles began to shift noticeably and new instructional patterns emerged. Team teaching, interdisciplinary project-based instruction, and individually-paced instruction became more common at all of the sites. To accommodate more ambitious class projects, teachers even altered the master schedule. Perhaps most important in this phase was an increasing tendency of ACOT's teachers to reflect on teaching, to question old patterns, to speculate about the causes behind changes they were seeing in their students.

Teacher Interaction

Along with the new instructional patterns came increased collaboration about instructional topics. As teachers developed technology-based learning experiences for students and adopted new teaching patterns, the frequency of their interactions increased and the substance of those interactions dealt more with instructional issues. The greatest degree of interaction occurred at sites that decided to formalize team teaching arrangements, a decision that was made by the teachers themselves, rather than being imposed by district or school administrators. Team teaching was most prevalent at the high school site, but gradually became more commonplace at the elementary levels. Given the differences in the contexts at each site, different team teaching configurations evolved, varying along such dimensions as the number of team members, student grouping, interdisciplinary approaches, and grade level assignments. As the benefits of team teaching became more apparent, ACOT staff encouraged this arrangement at all of the sites.

Team Teaching Obstacles

In the beginning, teachers frequently viewed team teaching as a great deal of additional work for relatively little gain. Some of the primary obstacles included differences in personalities, technical knowledge, teaching styles, grading policies, and approaches to discipline.

For some teams, personality differences created only minor problems as the teachers came to know each other better. However, other teams found that personality problems carried over from year to year and that they became extremely divisive.

> [One teacher] is not an easy person to talk with — he is always sure what he is doing is right. I'm not really sure what my role is sometimes. . . So we need to work this out. I wonder if the other sites have these personality problems. (AT, 7127, 9/27/88)

> I must say that the team teaching approach seems to create some friction; jealousies seem to arise when one teacher thinks another teacher is doing something that makes him or her look good and the other teacher look bad. I think it is unfortunate. We should dismiss our personalities and subjective feelings about things and get on with teaching. If we let students and their learning come first, everything else would fall into place. (AT, 7539, 12/13/88)

Differences in technical knowledge among teachers also led to conflicts and feelings of competition.

> As things become more competitive in terms of the use of equipment and software, and as some of us have become more competent, some of those who have been the "kings" have been challenged and are reacting in unfortunate ways which is creating some tensions. (AT, 610, 11/17/89)

One site decided to have a meeting for the ACOT teachers to air some of the feelings that were building up among the teams. At the meeting, the staff members were sensitive to one another, discussing issues and situations but avoiding personal attacks.

Teachers found it easy to agree in principle as they planned collaborations. However, when they began teaching together, differences became more obvious.

One such difference was teaching style. For example, in one team, one teacher believed in allowing students enough time to finish an assignment while the other teacher kept work self-contained and stuck to a pre-determined time schedule. Another team discovered they held divergent views about the structure of mathematics and their approaches to answering students' questions.

> I'm also trying to impress on him that math is not just the calculating in the problems he gives. The thinking process of setting it up is math, too. (AT, 412, 4/27/90)

> He answered a lot of questions for the students. The only problem is he'll sit down and do it, not tell them how to do it. (AT, 458, 5/16/90)

Like many teachers, ACOT teachers felt strongly about their teaching philosophies and styles. Consequently, they were resistant to changing their own style and were hesitant to impose their technique on other teachers. Moreover, while some teachers enjoyed working closely with colleagues, others were reluctant to relinquish their autonomy:

> Moving from an independent teacher to a team teacher without much preparation contributed a great deal to my feelings of aimlessness and lack of control. It worked but I was uncomfortable with it. I feel better about being in charge of teaching and the curriculum. (AT, 6052, 12/11/86)

Some teachers found that they were defining their team teaching roles differently. For example, one teacher felt it was okay to work on individual projects or to leave the room when the other person was "teaching." The other teacher felt a team approach involved more than a simple division of responsibilities.

> Those opportunities to fit things together don't come up unless you're right there in the classroom paying attention. He feels if I'm teaching there's no need for him to be there. (AT, 220, 10/27/89)

Inevitable differences in discipline and grading policies created initial obstacles to team teaching. Some teachers believed in making computerized summaries of scores and grades available to students while others felt such a policy created competition and emphasized grades over substantive learning. Teachers also expressed frustration over varying approaches to classroom management and discipline.

> I don't believe that [another teacher's] standards of discipline were the same as mine. She was very patient with the children and didn't use discipline techniques. Their behavior tended to get out of hand before she brought them back, which frustrated me. (AT, 1392, 6/13/90)

Differences in teacher attitudes and the organizational structure at the elementary and secondary levels led to different types of obstacles for those wishing to incorporate team teaching. For example, elementary teachers tend to exhibit less ownership over subject matter and frequently have prior experience working together. At the secondary school level, however, teams have to break through the established subject matter boundaries and overcome the independent orientation of the teachers. In most high school settings, teachers have adjusted to working in relative isolation and greatly value their independence.

Team teaching also requires planning time during the school day — an expensive, and at some sites, infeasible requirement. In elementary schools, teachers typically do not have a daily preparation period, inhibiting their ability to set up a common planning time. At both levels, the physical space and arrangement sometimes hinders the opportunity for spontaneous interaction and cooperative planning among teachers.

While some teams were able to overcome the obstacles inherent in team teaching, others eventually reduced the amount of team teaching or dropped the arrangement altogether.

> I really feel better about being solely in charge of my own classes. Now when I come in at off hours to work I know that I'm working for myself. You just don't feel the same when it's a team. I need to feel that student performance results directly from my teaching. (AT, 6057, 12/11/86)

Advantages of Collaboration

The sites that continued with team teaching found various ways to overcome the obstacles. Proximity between classrooms and offices facilitated greater contact among teachers. Cooperative planning was facilitated by allowing teachers regularly scheduled time during the school day for meetings.

> The fact that [the other team member] and I can sit down, coordinate lessons, and get a chance to talk is a very important thing to what it is we are trying to do out here. I need to campaign that all teachers should have that time to coordinate with a team teacher and how important that is to the learning process. (AT, 1143, 11/9/89)

Teachers also became more proficient at using available time. They learned how to interact with each other and how to prioritize and accomplish tasks during their planning time. Some of the most important tasks were setting goals and blocking out lessons so both team members understood what needed to be done. Having the time to plan reduced stress and eased tensions about "not knowing what direction we were going."

> As far as the team, what we expect from one another, it's so much more clear. Just getting to know each other, what they consider important, has really helped make this a very workable situation. I look back at my first year when I really wasn't sure about what was expected of me and how to function. (AT, 385, 3/21/90)

Successful teams also resolved personality differences and reached consensus about individual teaching styles, discipline policies, and the definition of team teaching.

> [Two teachers] are our experts and certainly role models for any study on how team teaching can and should be done. . . They strive to avoid the pitfall of thinking maybe they can get a few papers graded or write up a test or any of the other hundred of things they could be doing while the other teacher is "on." The first priority for the time the other teacher is leading the discussion is to support that person. Nothing else takes precedence. (WL,10254, 2/6/87)

> [Another teacher] and I are team teaching for another year. This time we're trying to spend more time actually team-teaching rather than just sharing the room. (WL, 12722, 10/13/88)

> We are always in the classroom together which is helping us integrate our classes and helping us check the students' work. As teachers, we can help with classroom controls. (AT, 2843, 11/18/87)

In addition, successful teams managed to reduce competition among teachers; instead they learned to draw upon one another's areas of expertise and specialized knowledge. Although problems reappeared periodically over the years, the benefits outweighed the obstacles, leading the teachers to stick with the teaming approach.

Those teachers who continued with team teaching began to reap the rewards of collaboration. They developed a strong camaraderie and gleaned support from one another.

> I appreciated their concern for me personally, especially when they made the first move with this kind offer to lighten my load. Another plus for team teaching. (AT, 3739, 5/16/88)

> It is so nice, when you are having a stressful day to have someone thinking about your needs. In a normal teaching situation, no one would even know what your needs are. (AT, 100, 8/29/89)

The joint planning sparked ideas among the teachers and increased their enthusiasm. At team meetings, teacher discovered ways to connect and improve upon activities and strategies they had tried individually. In addition, the discussions led to the development of new methods and became a powerful way of lesson planning. Moreover, the team approach allowed teachers to plan activities based on the strengths of each teacher.

> [The other team member] introduced the students to the network yesterday, and today I got to help reinforce what they had learned. I don't have enough confidence to teach the network from scratch. (AT, 7152, 10/11/88)

Teachers found that their varying approaches could be complementary and benefit rather than hinder student learning.

> [The other team member] was telling me that she was really impressed with the different way I covered the use of the trig functions today and how well that complemented what she had done. She thought the kids would come away with a better understanding. (AT, 1139, 11/7/89)

During instruction, they were able to provide more individual help to students.

> We had two pages of requests for individual attention on our sign-up list. That's 60 questions out of a class of 30 kids. There is no way you could do that in a period with one teacher. (AT, 3659, 11/4/88)

> Working with smaller groups seems to be a benefit. People seem to be on task more often and paying attention and I think we're accomplishing more. (AT, 1221, 2/2/90)

The team approach also allowed more flexibility with respect to grouping students. For example, one team decided to have one teacher take small groups to the biology lab while the other remained in the classroom. This decreased the amount of lab equipment needed and made it easier to monitor students and answer questions. Other teachers tried a similar strategy with the chemistry class. Even within the classroom, teachers could work with smaller groups requiring help in particular areas. In addition, teachers could vary their teaching assignments with small groups.

> I am pleased with the way Algebra 1 has turned out. We have the students working in two groups, and [the other teacher] and I switched groups this week. She was getting frustrated with the group she had that just didn't follow through. So it was a good idea just to shift to keep from getting burned out on one group. This wouldn't have happened in a regular classroom. (AT, 7771, 2/28/89)

The teachers also reported that teaming increased what teachers were able to accomplish during a class period and made it easier to spot patterns of student misunderstanding.

When a team member was absent, the instructional program continued on schedule — unlike what occurred previously with substitute teachers.

> In the past, I would have had to worry about materials for substitutes ahead of time and then worry whether the sub did what I wanted after I got back. But with the team teaching it is great. (AT, 4373, 2/24/88)

> Classes just go on whether we have a teacher here or a sub or not. It's really working great in terms of the team knowing what each other's doing and being able to cover when somebody is out. (AT, 8095, 4/5/89)

Without the concern over the progress of their classes during absences, teachers felt more comfortable about attending professional conferences scheduled only during the school year.

Collaboration and Interdisciplinary Teaching

The team teaching arrangement allowed both elementary and secondary teachers to develop and implement interdisciplinary curriculum — a rare situation in most secondary schools. Interdisciplinary teaching occurred across a variety of subject areas such as math/science, Life Skills/English, history/literature. Teachers also combined a number of subject areas into one class; for example, a class called "Strategies" included math computation, problem-solving, science, and health.

As the teachers became involved in cross-disciplinary teaching, they began to identify a number of benefits. The students started to understand the integration among subject areas, instead of viewing them as separate, unrelated subjects.

> The students don't differentiate between math and science now. It is exciting to have an opportunity to work in an interdisciplinary way. (AT, 240, 11/14/89)

Students exhibited greater interest in their work and started to ask questions indicating their integration of subject areas.

> In the course we are teaching — American literature and history together— the students are really putting the two together . . . It will help them learn two areas which in the past students thought were boring. Now they are thinking and asking questions about it. (AT, 1, 10/7/88)

In addition, teachers discovered that the students in their team-taught classes could handle more advanced material than in the traditional classes.

> [One teacher] sees a great difference in the amount of understanding the ACOT students have as compared with the students in his two regular classes that do not have the luxury of the teaming approach with the mathematics teacher. (WL, 10190, 12/12/86)

> In the past, students have had a hard time determining which trig function to use to solve the triangle, no matter how much we go over it. Now they see it in math and physics classes. (AT, 236, 11/8/89)

A math/science team found that they were teaching concepts that other science teachers avoided because they believed the students couldn't do the math involved. The integration also helped the math/science teams in their goal of helping students to develop problem solving skills in mathematics rather than simply seeking solutions.

The teachers noted an increase in their own enthusiasm and knowledge as they became involved in interdisciplinary teaching. Their abilities to mesh their curricula exceeded their initial expectations. At the secondary level, the strong subject matter boundaries started to diminish, and teachers began to seek out instructional resources and opportunities in other subject areas.

> Team teaching is interesting because I concentrate on math, but I try to think of the science applications of it. I look for more ideas and materials than I would as a solitary teacher. (AT, 238, 11/10/89)

At one site, the team teaching and interdisciplinary approach developed by the

project teachers became a model for classes throughout the school and district. A principal at another high school in the district, highly impressed with the approach, located funding for modifying the model and developing curriculum that could be replicated in other urban schools — even without the high-access-to-technology.

SUMMARY

This study points out the symbiotic relationship between innovation and collegial interaction. The innovation, high-access-to-technology classrooms, drove teachers to more collegial interaction and instructional sharing. But teachers in schools with a high level of collegial interaction embraced the innovation and implemented new instructional strategies more quickly.

The instructional changes among the teachers corresponded closely with changes in collegial interaction. In the entry stage of the project, the teachers demonstrated little penchant for significant instructional change, and their collegial interaction was infrequent and focused on emotional support. In the adoption stage, teachers used the technology to support traditional instructional and learning activities; collegial interaction increased but included primarily technical assistance. The adaptation phase brought changes in the efficiency of the instructional process, and the substance of their interactions included the sharing of instructional strategies. As teachers eventually reached the appropriation phase, their roles shifted and new instructional patterns emerged. Similarly, teachers engaged in greater collaboration about instructional topics. At many sites, the increased collaboration led to team teaching and interdisciplinary instruction.

At first, teachers viewed team teaching as more demanding than beneficial. But as sites continued with team teaching and found ways to overcome the inherent obstacles, the benefits began to emerge. Eventually, team teaching led to cross-disciplinary teaching which held additional advantages for both teachers and students. Table 3 summarizes the advantages of team teaching for the teachers.

Advantages of team teaching
• Shared responsibilities
• Increased camaraderie, enthusiasm and support
• Development of activities based on teacher strengths
• Development of new ideas and teaching methods
• Utilization of approaches that promote student understanding
• Increased individual help for students
• Increased flexibility in grouping students
• Increased amount accomplished during class period
• Greater ease in identifying student misunderstanding
• Continuity of instructional program when one teacher is absent
• Development of an interdisciplinary curriculum
• Greater student ability to handle more advanced material

Table 3: Advantages of Team Teaching

IMPLICATIONS

This paper highlights four main issues relevant to practice and research. First, the adoption of innovation and the creation of a collaborative environment are complementary conditions for change. Individuals interested in school change need not focus only on one condition. Change occurs most quickly in environments where innovation and collegial interaction are operating simultaneously, each enhancing the other.

Second, in line with the beliefs of those attempting to restructure schools (David, 1990; David, Cohen, Honetschlager, & Traiman, 1990), our reflections on ACOT's experiences support the idea that structural and programmatic shifts in the context or working environments of teachers who are learning to use innovative technology are critical. The current nationwide movement toward restructuring the entire school system — including the curriculum, the way students are taught, and the way schools are governed — seeks to attack the problem of change from multiple levels simultaneously. Unlike previous reform efforts, the reconstruction movement acknowledges that innovations introduced at only one level of the system are not likely to succeed.

Lasting, significant change will not occur simply by giving teachers the latest technological tools. Rather, teachers must be provided with on-going support which is available only if the larger system in which they are working changes as well. Organizational supports for ACOT teachers included:

- training workshops
- on-going technical support
- release time to attend professional conferences
- time during the school day for joint planning and team teaching
- a telecommunications network that allowed interaction across sites and with the ACOT project staff
- the opportunity for routine peer observations and group discussions.

To accommodate their instructional innovations and interdisciplinary approaches, one site was even allowed by the school and district to alter the master schedule.

Third, not only can restructuring enhance the adoption and integration of technology—or any innovation, for that matter—but the introduction of technology to schools can act as a catalyst for change, thereby enhancing restructuring efforts.

> Technology clearly has the potential to vastly transform relationships between teachers and students and even what schools look like. However, the history of education reform provides scant evidence that such a transformation will occur simply because the technology exists. Schools have demonstrated an unyielding resistance to change over the decades. Reforms that are adopted tend to be those that readily fit existing organizational structures and practices (David, 1990, p. 76)

In the case of ACOT, the introduction of technology had a direct impact on the way teachers worked with one another: there was more emotional support, more sharing of instructional ideas, and more collegial interaction because teachers sought each other out in their attempts to adapt to their innovative classrooms. Perhaps, in the scheme of things, this is a relatively small change, but the reduction of teacher isolation is an important part of reconstruction.

Finally, the experience of the ACOT project demonstrates the value of taking a long-term perspective on change. Data from this five-year study illustrate that, even when classroom environments are drastically altered and teachers are willingly immersed in innovation, change is slow, and sometimes includes temporary regression. Unfortunately,

agencies or organizations funding innovative programs often expect to see measurable progress or change within a short time. In line with other research on teacher change, the data suggest that teacher commitment to an innovation will not occur until they see a positive impact on their teaching. Moreover, those searching for a way to assess the impact of innovation should not expect to see a clear progression through stages. Problems of implementation and adoption may arise, disappear, and then reoccur as teachers and students adjust to the innovation.

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